OCR
RECOGNISING ACHIEVEMENT

ADVANCED GCE

2806/01

BIOLOGY

Unifying Concepts in Biology

TUESDAY 19 JUNE 2007

Morning

Time: 1 hour 15 minutes

Additional materials: Electronic calculator
Ruler (cm/mm)

Candidate Name

Centre Number

Candidate Number

INSTRUCTIONS TO CANDIDATES

- Write your name, Centre Number and Candidate Number in the boxes above.
- Answer **all** the questions.
- Use blue or black ink. Pencil may be used for graphs and diagrams only.
- Read each question carefully and make sure you know what you have to do before starting your answer.
- Do **not** write in the bar code.
- Do **not** write outside the box bordering each page.
- WRITE YOUR ANSWER TO EACH QUESTION IN THE SPACE PROVIDED. ANSWERS WRITTEN ELSEWHERE WILL NOT BE MARKED.

INFORMATION FOR CANDIDATES

- The number of marks for each question is given in brackets [ ] at the end of each question or part question.
- You will be awarded marks for the quality of written communication where this is indicated in the question.
- You may use an electronic calculator.
- You are advised to show all the steps in any calculations.

FOR EXAMINER'S USE		
Qu.	**Max.**	**Mark**
1	**14**	
2	**11**	
3	**12**	
4	**10**	
5	**13**	
TOTAL	**60**	

This document consists of **18** printed pages, **2** blank pages and an insert.

Answer **all** the questions.

1 Sea slugs are marine molluscs. Some are pictured in Figs 1.1 and 1.2 **on the insert**. Sea slugs live in shallow coastal waters where they graze on animals that form colonies on rocks, like sponges and corals. Sea slugs are preyed upon by fish.

Many sea slugs collect poisonous chemicals or defences such as stinging cells from their prey. They then make use of these in their own bodies. Sea slugs containing poisonous chemicals or other defences are generally brightly-coloured.

Sea slugs evolved from sea snails by the loss of the shell. It is thought that being brightly-coloured is an advantage to poisonous animals as predators learn to avoid them.

(a) Suggest why being poisonous or brightly-coloured is more common in species of sea slug than in sea snails.

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.... [2]

(b) A student set up an experiment to test whether fish could learn to associate an unpleasant taste with a particular colour.

- A tank 0.6 m long containing two goldfish was used.
- At one end of the tank five pieces of untreated floating fish food were placed once a day into a red plastic ring suspended at the water surface.
- At the other end of the tank five pieces of food that had been soaked in a bitter chemical were placed in a yellow plastic ring at the surface.
- The student observed how many pieces of food were taken from each ring within twenty minutes of feeding time.
- The experiment ran for ten days.

Suggest **three** improvements that should be made to this experiment in order to collect valid data.

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(c) The waters of South-Eastern Australia are home to a group of sea slugs found nowhere else. Ten distasteful species of the genus *Chromodoris* all share a pattern of bright red spots on a white background. This is an example of mimicry. Four of the *Chromodoris* species are shown in Fig. 1.1 on the insert.

(i) Explain why one warning pattern shared by ten species gives a greater **selective advantage** to the slugs than if each had its own distinctive warning pattern.

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(ii) Describe how a South-Eastern Australian sea slug population that was originally white might have developed the red-spotted pattern over a period of time.

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(d) *Pteraeolidia ianthina*, shown in Fig. 1.2 on the insert, is a sea slug whose body is covered in hundreds of cerata. The cerata are extensions of the body wall. Inside each extension is a duct filled with brown photosynthetic algae. *P. ianthina* obtains the algae from its coral food and keeps them alive within its tissues. Its strange body shape allows it to host more of these organisms.

Explain what benefits the sea slug might gain from the photosynthetic algae contained in its body.

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[Total: 14]

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2 Table 2.1 shows the approximate size and number of stomata in the leaves of three plant species.

The data were collected by taking photographs of pieces of leaf placed under a microscope. The length and width of a large number of stomata visible on the photographs were measured.

Table 2.1

species	mean number of stomata per mm^2 on lower epidermis	mean length of fully open stomata / μm	mean width of fully open stomata / μm	mean area available for water loss through fully open stomata / μm^2 per mm^2
Phaseolus vulgaris (bean)	281	7	3	5901
Hedera helix (ivy)	158	11	4	6952
Triticum sp. (wheat)	14	18	7	1764

(a) **(i)** Explain why a large number of stomata are measured in order to calculate a mean.

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(ii) Suggest **two** ways in which photographing the leaf surfaces makes measuring the stomata easier.

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(b) The mean area available for water loss shown in the last column of Table 2.1 was calculated as follows:

- multiplying the mean length by the mean width to find the area of one stomatal opening
- multiplying this figure by the number of stomata per mm^2.

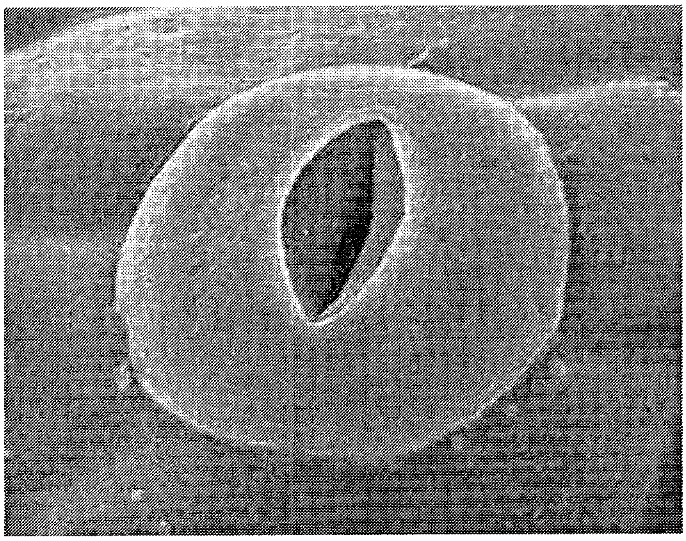

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Fig. 2.1

Fig. 2.1 is a scanning electron micrograph of a stoma. Use Fig. 2.1 to suggest why the figures calculated for the area available for water loss are not accurate.

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.... [1]

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(c) Abscisic acid (ABA) is a plant growth regulator synthesised in leaves. In an investigation into the effects of ABA on stomata, a previously well-watered maize plant was not watered for five days. The following measurements were taken:

- the water potential of leaves;
- the resistance to the flow of air through the stomata;
- the ABA content of leaves.

When the stomata are fully open, the resistance to the flow of air is low. The plant was watered again at the beginning of day 6 of the investigation.

The results are shown in Fig. 2.2.

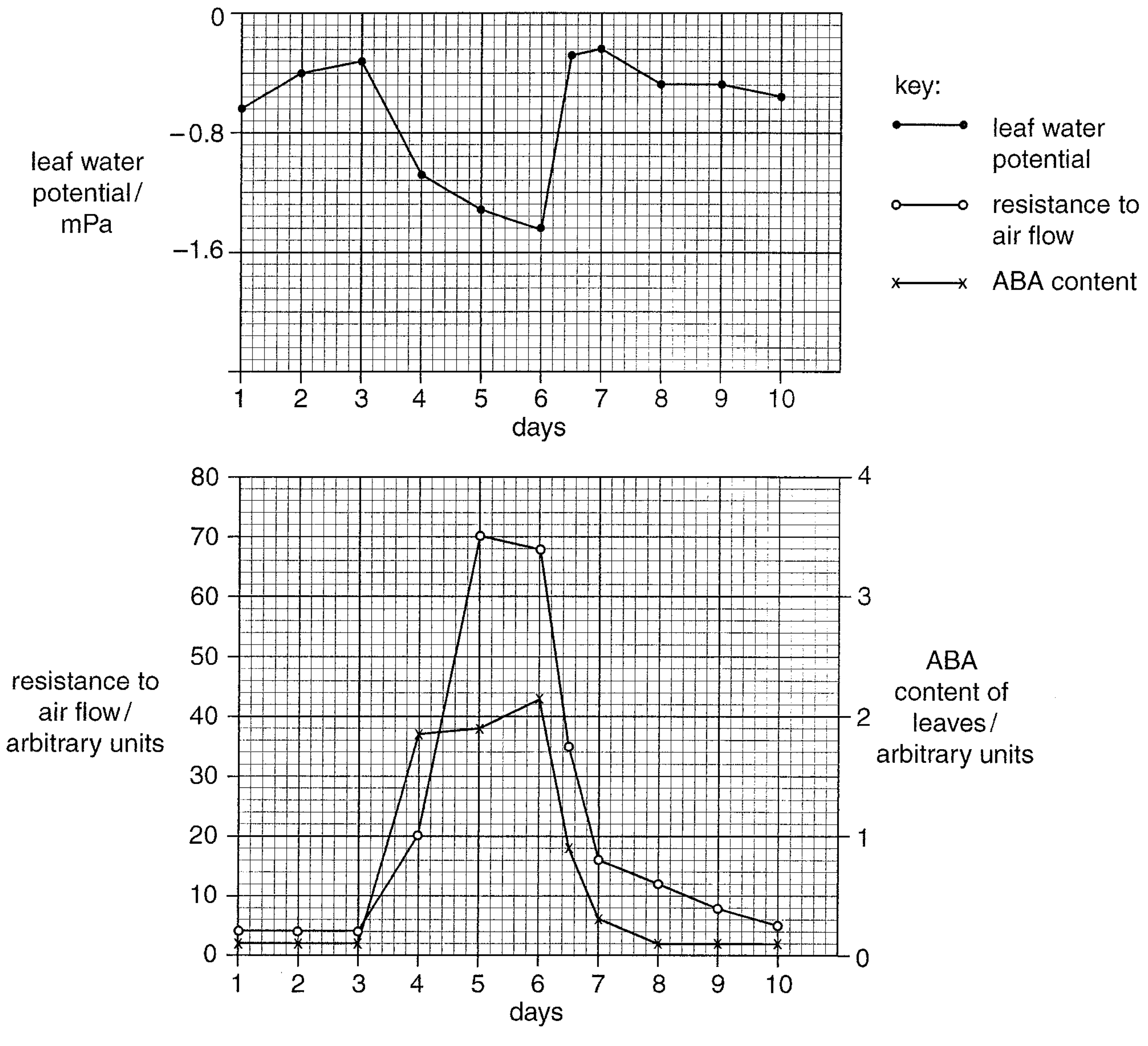

Fig. 2.2

(i) Explain the **decrease** in the water potential of the leaf between days 3 and 6, as shown in Fig. 2.2.

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(ii) It is suggested that ABA is synthesised during times of water stress to cause stomata to close.

Use Fig. 2.2 to comment on this hypothesis.

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[Total: 11]

3 Coral reefs occupy 0.2% of the world's oceans but provide habitat and breeding grounds for 25% of the world's fish species. Fig. 3.1 shows a food web for a coral reef community.

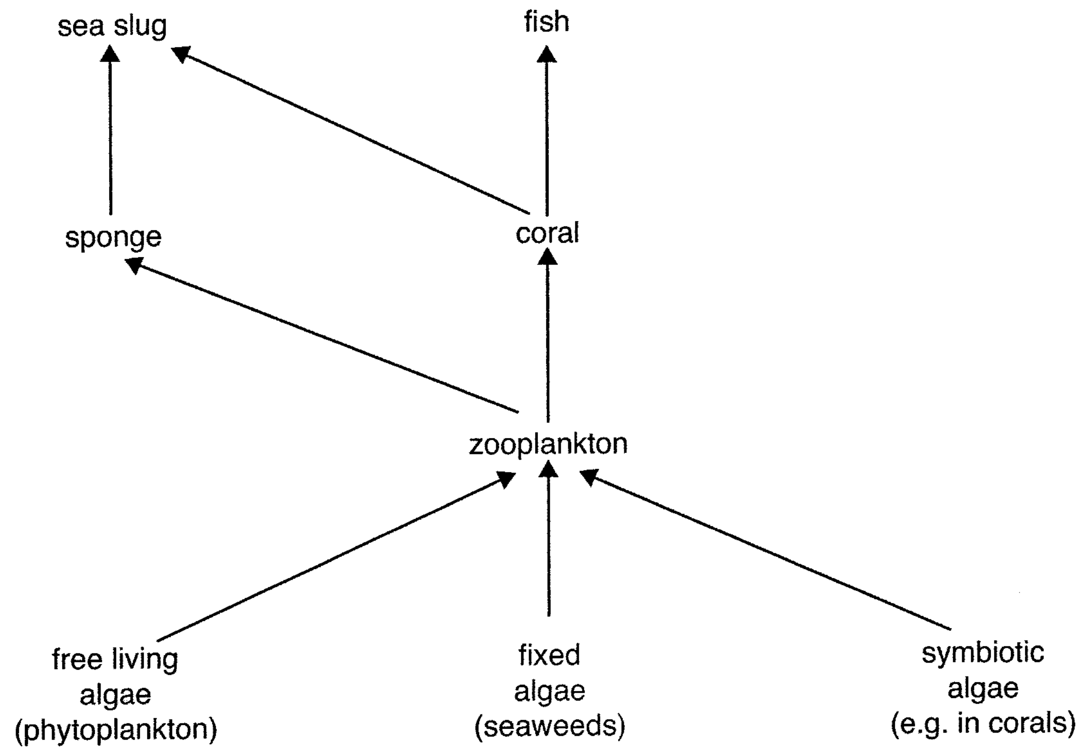

Fig. 3.1

Reefs are under threat from a variety of sources. One of these is the water that drains from agricultural land that is rich in fertilisers. Another is the discharge of untreated sewage into the sea.

(a) Explain how these forms of pollution could alter the ecological balance of a coral reef.

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(b) In this question, one mark is available for the quality of spelling, punctuation and grammar.

The immense biodiversity of the oceans includes:

- corals that host symbiotic algae which die if the sea temperature rises by 1 °C;
- animals like polar bears that use floating ice as a base for sea fishing expeditions;
- sessile animals like mussels that feed by filtering food particles from the water and reproduce by releasing gametes into the water;
- reef-building animals like corals that form hard calcium carbonate skeletons by extracting mineral ions such as Ca^{2+} from the water;
- seaweeds of different colours which occur in shallow water;
- animals like fish that hunt prey using well-developed visual skills;
- large animals such as the blue whale;
- physically delicate organisms like jellyfish that lose their shape in air.

Using examples from the list above, describe **and** explain how the **properties** of water make it a suitable environment for these organisms.

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[7]

Quality of Written Communication [1]

[Total: 12]

4 Recent data shows that organisms vary widely in the size of their genomes. Fig. 4.1 shows the number of functional genes plotted against the total length of DNA in six organisms. The length of DNA is measured in numbers of base pairs.

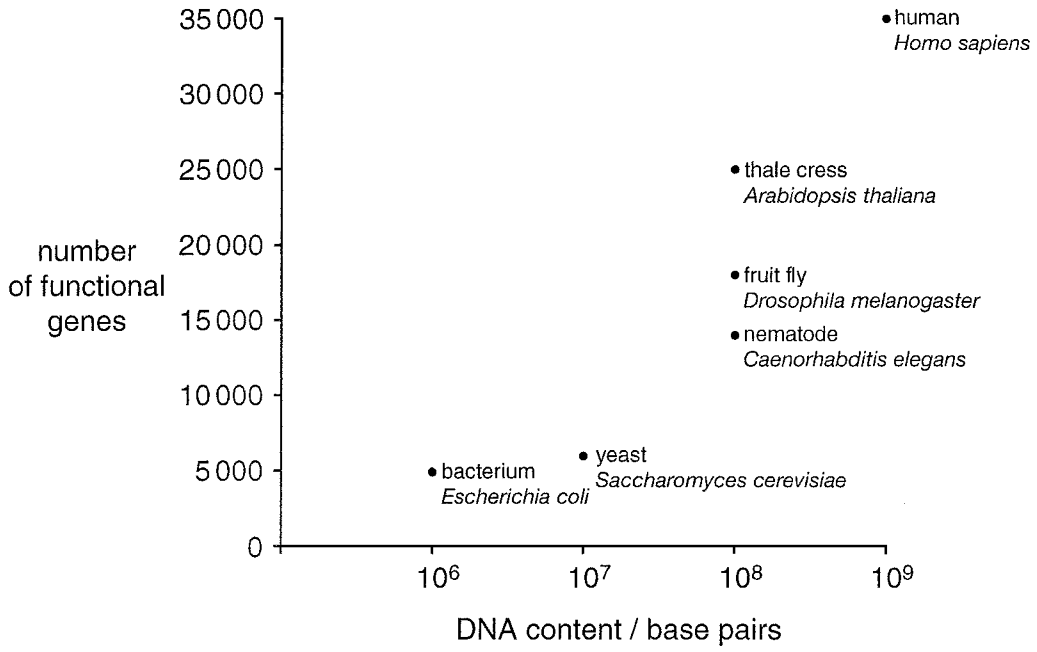

Fig. 4.1

(a) Fig. 4.1 shows that the human genome contains only about seven times as many functional genes as the bacterium *Escherichia coli*, but consists of about a thousand times as much DNA.

Suggest why humans have so much extra DNA despite having only seven times as many functional genes as the bacterium *E. coli*.

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(b) A double-stranded DNA molecule is 2 μm long for every thousand base pairs.

Use Fig. 4.1 to calculate the total length of DNA in a human cell. Show your working.

Answer = ... [2]

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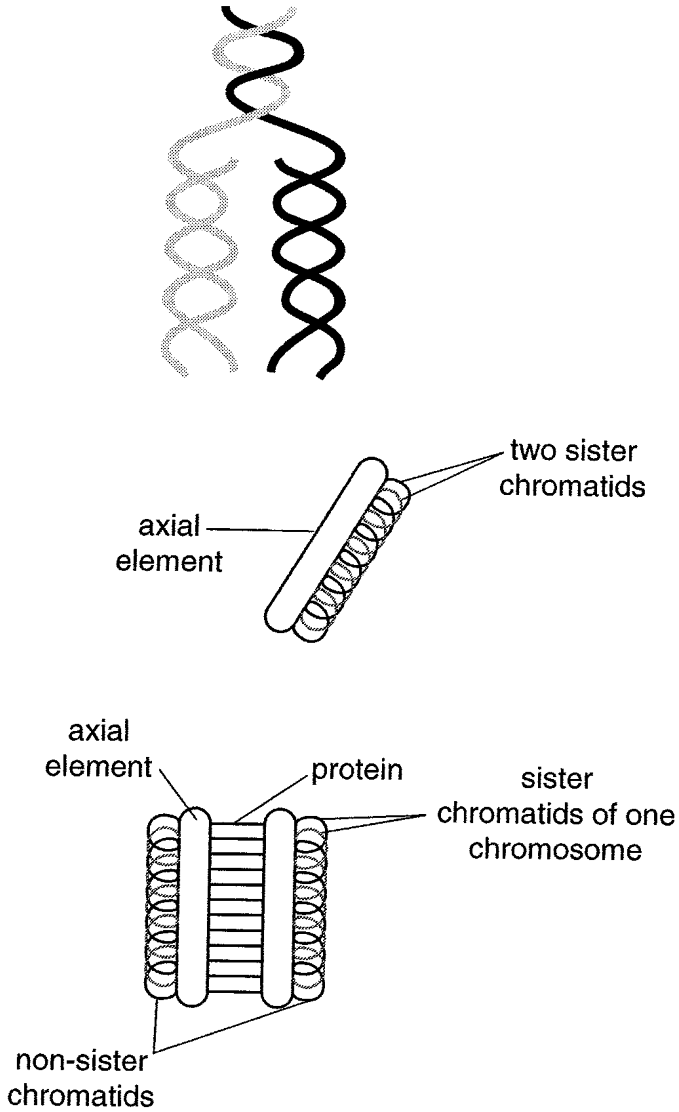
(c) Fig. 4.2 shows events leading to the formation of homologous pairs in meiosis.



- DNA **replicates** during interphase forming two sister chromatids.
- Both sister chromatids attach to a protein rod called the axial element.
- The axial elements of homologous chromosomes come together in the formation of a homologous pair (bivalent).

Fig. 4.2

(i) Explain why the DNA in two sister chromatids is identical.

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.... [2]

(ii) Explain why the DNA in two sister chromatids in metaphase may no longer be identical.

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(iii) Suggest why axial elements are necessary in meiosis.

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[Total: 10]

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5 Hepatitis is an inflammation of the liver which may be caused by viruses, alcohol and drugs. Symptoms include jaundice, fever, nausea and high levels of liver enzymes in the blood. The hepatitis A virus causes acute disease only, but hepatitis B and C viruses can cause chronic disease which results in destruction of liver cells.

(a) **(i)** Roles of the liver include urea synthesis, converting one amino acid into another and the break down of ethanol and lactic acid.

State the name of a liver enzyme that might be released into the bloodstream if liver cells become damaged.

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(ii) Explain the difference between a chronic and an acute disease.

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.... [2]

Liver cells damaged by hepatitis infection switch on a gene called Fas, which causes them to self-destruct. Pioneering research has produced a strikingly successful treatment for hepatitis in mice. The Fas gene was silenced by the technique of RNA interference.

RNA molecules, 21 to 23 nucleotides long, were injected into mice with hepatitis. The sequence of this 'small interfering RNA' (siRNA) matched part of the Fas gene. Once in the liver cell the two strands of the siRNA were separated so that one strand could bind to the mRNA transcript of the Fas gene. This caused the mRNA to be destroyed by enzymes, therefore preventing the gene product from being made.

This therapy prevented liver cell death and considerably increased the survival of mice with hepatitis.

(b) **(i)** Describe a way in which the **function** of mRNA differs from that of DNA.

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.... [2]

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(ii) Describe **two** ways in which the **structure** of siRNA differs from mRNA.

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(c) Describe how one strand of the siRNA can bind to the mRNA of the Fas gene.

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.... [3]

The technique of RNA interference has also been used to slow replication of HIV (Human Immunodeficiency Virus) *in vitro*. siRNA sequences that match the RNA genome of HIV can be used to trigger destruction of this RNA, preventing HIV from multiplying.

Another approach is to use RNA interference to silence genes for cell surface receptors, such as the CD4 and CCR5 molecules on human white blood cells. If these genes do not produce their protein antigens, HIV cannot bind to and infect the white blood cells.

(d) Table 5.1 summarises some information about the two cell surface receptors used by HIV to bind to and infect white blood cells.

Table 5.1

	cell surface receptor	
	CD4	CCR5
type of cell with this receptor	T lymphocyte white blood cells which divide by mitosis	macrophage cells which are long-lived and do not undergo mitosis
function of receptor	important roles in the immune system	limited, since 1% of people lack this receptor and show some resistance to HIV

Experiments have been carried out where,

- siRNAs matching the CD4 mRNA were introduced into test tube populations of T lymphocytes;
- siRNAs matching the CCR5 mRNA were introduced into test tube populations of macrophages.

In both cases HIV was present but the presence of the siRNAs reduced its replication.

(i) Use Table 5.1 to suggest with reasons which of the two test tube experiments showed most reduction of HIV replication.

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.... [2]

(ii) Explain which receptor would be the best target for RNA interference if the approach was used as a therapy for humans infected with HIV.

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.... [1]

[Total: 13]

END OF QUESTION PAPER

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BIOLOGY

Unifying Concepts in Biology

INSERT

TUESDAY 19 JUNE 2007 Morning

Time: 1 hour 15 minutes

CUP/T26299

INSTRUCTIONS TO CANDIDATES

- This insert contains Fig. 1.1 and Fig. 1.2.

This insert consists of **2** printed pages.

SP (MML 12703 1/06) T26299/4 **[Turn over**